Infestation of *Euryale ferox* Salisb. by larvae of *Nymphula crisonalis* Walker and trials on its Control

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(*With four text-figures*)

Introduction

The aquatic herb, *Euryale ferox* Salisb., of the family Nymphaeaceae is extensively cultivated in the district of Darbhanga in North Bihar. The habitat chosen for its cultivation are generally the age-old perennial ponds having shallow beds subjected to flooding during rains from the neighbouring streams. Seeds of the plant are parched and beaten and the decoated seeds thus obtained are sold as a highly priced food, the current market rate being rupees eight to ten per kg. Usually, five to six quintals of the seed are annually collected from one acre cultivation, which, in the form of dry edible seed, is one-third of this produce. Obviously, the annual sale proceeds, under normal conditions, exceed rupees one thousand five hundred per acre. The expenditure incurred over its cultivation is very modest as the seeds left over after harvesting germinate out as crop for the next season and it is only the labour which involves some expenditure in thinning out the overgrowths, transplanting into the sparse areas, and in collection of the dispersed seeds from the pond bed during the time of harvesting. Cultivation of this crop, including decoating of the seeds and disposal of the finished produce, happen to be vocation of the fishermen, who, in addition, get some revenue by taking out fish from the water after the main crop is harvested. The significance of this crop, which is so intimately linked up with the livelihood of the fishermen community, can be judged from the fact that on an average 200 quintals of the seed, locally known as ' Makhana ', are transported each year from Darbhanga, besides local consumption.

Lately, the cultivators have complained about the attack on their crop by a caterpillar pest which sometimes assumes menacing proportions. The larval pest, besides eating the blades of early leaves, cuts and rolls a portion of the leaf lamina as a shelter. Earlier attempts to control the pest were limited to picking them off as far as possible. Currently, the cultivators have resorted to indiscriminate use of all kinds of pesticides endangering the fish fauna and the food chain in the aquatic environment.

The present study was undertaken to identify the pest, observe the stage of the plant most susceptible to attack, and to find out a suitable pesticide for its control that would least damage the indigenous fish life and other aquatic biota.

Materials and Methods

Soon after the new set of plants sprouted, close observation was kept to watch the successive stages of the larval pest. Specimens of the infested plants, with caterpillar *in situ*, were removed to the laboratory in earthern pots filled with water and specially prepared for the purpose with a layer of pond silt at the bottom. These pots were covered with fine mesh cloth netting and kept in the open space to provide natural light. At the pupal stage they were carefully detached along with their leaf-lining and floated on water in glass jars covered with netting but with sufficient space for the emerging adult. For first hand information on the dosage of selected pesticides, trials were conducted in large glass jars containing larvae on the leaf blades as in nature. Final trials, on the basis of this information were conducted in large tubs where field conditions were simulated as far as practicable, including transplant of zooplankters and the fish fauna commonly encountered in the *Euryale ferox* habitat.

Results

Susceptible stage of growth of the plant : To recognise the stage of the plant most susceptible to attack by the pest, it is necessary to describe the chronology of foliaceous growth of *Euryale ferox*. Although described as a perennial aquatic herb (Haines 1925 ; Calder & Biswas 1936 ; Subramaniam 1962), the plant, as observed under cultivation here, behaves as a long seasonal or at the most an annual. Fruits mature and burst between September and December and the globular seeds drop to the pond bed. At this stage, fishermen root out the plants as far as possible to facilitate collection of the seeds. It has been observed that, with the onset of winter, the remaining plants also die out. From February onwards, the seeds left over on the pond bed, or those subsequently broadcast, start their hypogeal germination. It may be mentioned here that the thick fibrous roots of the plant described by Calder & Biswas (op. cit.) are actually comprised of 3 to 4 clusters, each cluster containing about 17 rootlets. As the new plant sprouts, the cluster of rootlets come out one after another at an interval of one week or so. Likewise, the foliage pattern also exhibit definite sequence in their appearance. The description given by earlier workers about the large, orbicular, corrugated and peltate leaves with strong spines actually represent the foliage of the fully developed plant, when all the cluster of

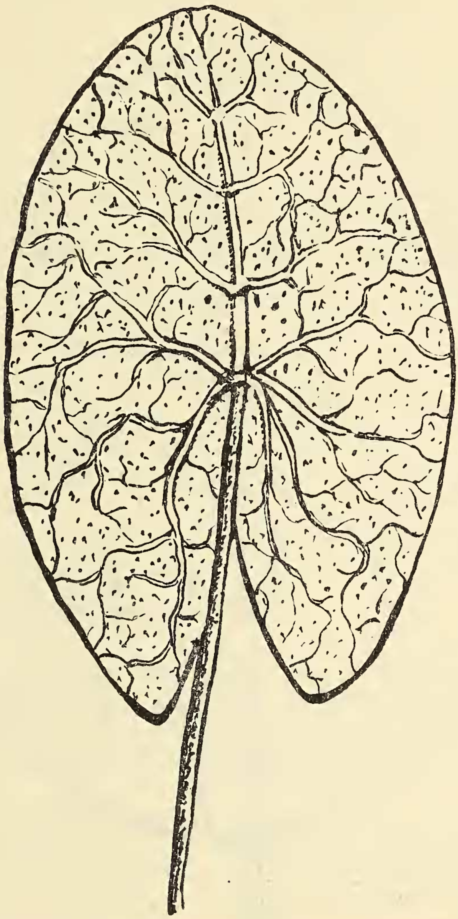

Fig. 1. Leaf of *E. ferox* from the first set.

rootlets have come out and the plant is deeply set in the pond bed. In appearance, the early leaves are quite different from older ones. The first set of leaves are membraneous, deeply sinuate and at the maximum 9 cm long and 8 cm broad. They are deep-pinkish in colour on both the dorsal and the ventral sides, and the stalks are correspondingly tender, having little or no prickles on the lamina. The second set of leaves appear after a fortnight and are more orbicular, moderately sinuate, green above and purplish below, and measure about 15 cm at the longest part with corresponding breadth of 14·5 cm. Their veins are more prominent with spines at places and the petioles are also stiffer, thicker and spiny compared to the leaves of the first set. The typical leaves in the maturing plants start appearing a fortnight later. These are rugose, orbicular, with a slight notch and are green above and dark-purple below. Depending upon the spread area, these leaves vary in

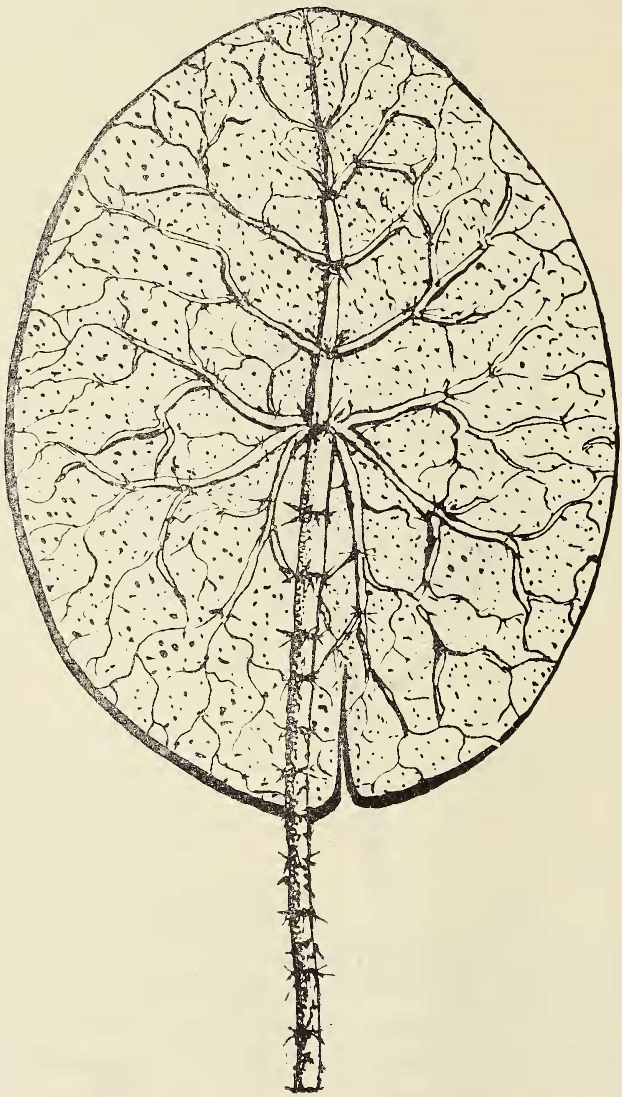

Fig. 2. Leaf of *E. ferox* from the second set.

length and breadth from 30 to 120 cm and 25 to 110 cm respectively. The veins are highly swollen on the ventral side and are beset with sharp spines which are also profuse on the leaf stalk.

The foliaceous chronology in the growth of the plant as observed above seems to be an ecological adaptation for its survival. Being a shallow aquatic herb, even moderate surface disturbance has effect right up to the root. The first cluster of roots, would have run the risk of loosing anchor were the early leaves as broad and buoyant as the typical leaves. However, the adaptive feature, while helping the plant to circumvent the hydrological risk, has left it open to the biological risk of the insect pest. As observed in nature, the plants are vulnerable to the pest as long as the earlier set of leaves predominate, but as the broad bladed typical leaves start appearing, it can be taken that the plant has turned the corner, as far as damage from the pest is concerned. A notion prevailing among the cultivators that, with the appearance of the typical leaves, the season for proliferation of the pest was over and that they disappear from the pond was not correct because in the same pond, which had their early leaves of *E. ferox* intensively hit by the larval pest, the larvae continued to be in abundance on another aquatic herb, *Nymphoides cristatum*, growing along the pond margin, after abandoning *E. ferox* with the emergence of typical leaves. It appears the disappearance of the larval pest from *E. ferox* at later stages is linked with the unsuitability to the larvae of the coarser lamina interlaced with rugged veins of the typical leaves.

The early leaves of *E. ferox* also at times swarm with aphids. However, aphids alone do not constitute risk, but the situation is different when the caterpillar attack is already there.

Larva : The late instar of the larva is 15 to 20 mm long and 3 mm wide at the broadest segment. Mandibles rather small. There are between 60 to 100 lateral gills, some of which branch dichotomously. The active larva is yellowish green with a darkish longitudinal streak in the middle of the dorsal surface.

Besides the appearance, the habits of the larval pest as observed conformed to the behaviour of *Nymphula* group described by earlier workers for the species found in their area. Welsch (1966) described the larval case as oval to oblong, filled with water and made out of leaf of the aquatic plants such as *Nuphar*, *Potamegeton*, *Vallisneria* and others found in quiet waters. Clegg (1956), while describing the China mark moths and their larvae, observed later instar of larvae making some kind of protective case from pieces of floating leaf like that of water lily, glued together by their silky secretion. Hampson (1896), while describing the Indian moths, observed that the larvae of some species of *Nymphula* feed on water plants and are best suited for life under water. He, however, did not mention the names of host plants and the details of infestation.

The *Nymphula* larva as pest on *Euryale ferox* was observed in this case to cut the blades of early set of leaves, either in the middle or at the margins, flapping it down the ventral surface or turning it over dorsally, and then gluing it into an oval case 20 to 30 mm long. Under field conditions, the larvae were hardly seen out of their cases. In the labora-

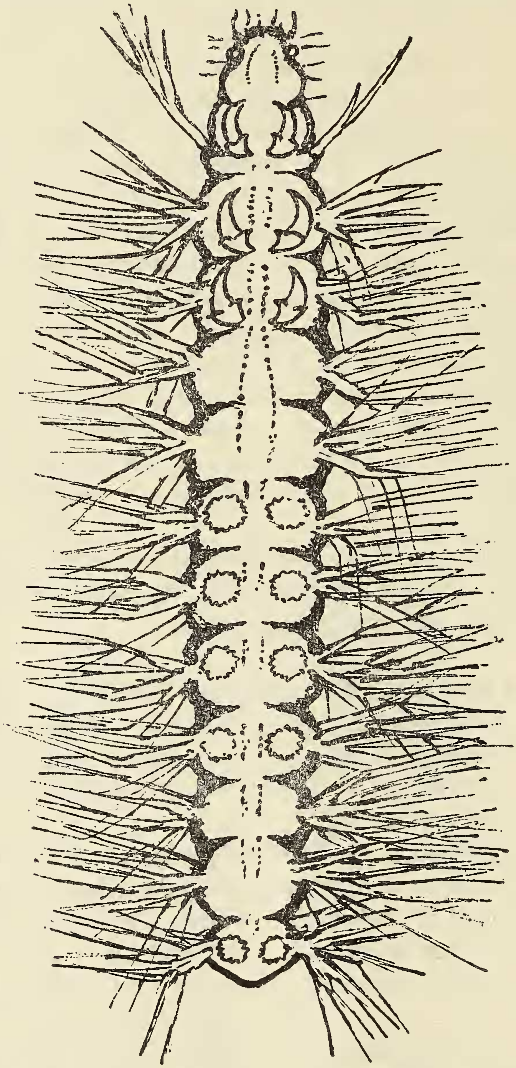

Fig. 3. Ventral view of the larva of *Nymphula*.

tory lamina of some of the leaves with the larval case decayed excepting the portion which actually formed the larval case which therefore separated from the plant. The larva then projected its anterior end out of the case and swam about executing jerks alternately on each side, thus pulling the case along till it came across a fresh leaf in which it made a new shelter. Larva moving with leaf case has also been described by Berg (1950) in the case of *N. obscuralis*. It was also observed that once the immature larvae are out of their cases in search of fresh leaves and drop off the plant during the process, they crawl at the bottom and along the stalk until they anchor on to a fresh leaf. The lateral gills are distinctly spread in water, but as soon as they are taken out of water, the gills collapse and become indiscernible. Deprived of moisture, the larvae did not survive for more than a few hours even on the leaves.

Pupa : The later instars of the larvae brought to the laboratory started pupating in 4 to 5 days. The late instars of the larvae and the pupae were found in abundance on *E. ferox* from early March to middle of April. The larval leaf case serves as outer lining for the pupal cases

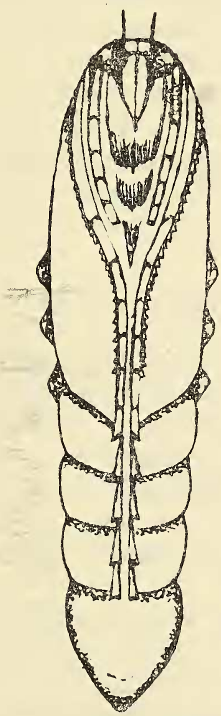

Fig. 4. Ventral view of the Pupa of *Nymphula*.

which has yet another padding inside of a silky material. The pupae are 9 to 12 mm long and are of cream colour, including the wings and the appendages save the antennae which are brownish. Before the adult emerges the shade darkens. The wings and appendages are neatly drawn along the ventral side of the body. The wings are not contiguous at any point and are separated out by the appendages. The antennae originate dorsally anterior to the eyes, turn ventrally, and run along the margin of the wings terminating a little ahead of the latter's tips. Metalegs reach near the abdominal segments, and the spiracles on the second, third and fourth abdominal segments are all equally prominent and are stubby in appearance. The pupae are found both on the dorsal and ventral surface on the leaf. It was also observed that, if detached from the plant, the pupae float on the water surface and survive as long as they retain the leaf lining. However, if they lose their leaf case, they fall to the bottom and perish.

Adult : A few larvae in their cases were floated on water in separate jars which were covered with cloth netting. The larval cases were taken out at regular intervals and the time of metamorphosing to pupa was noted by moving apart the leaf lining slightly. In all cases observed the pupation was found to last for 11 days. Emergence of the adult from the pupa was always found to be during the night, similar to the observation of Berg (op. cit.). The wings of the adults have chocolate brown ground colour with obscure markings. A thin tawny yellow curved band is noticeable on the forewing. When spread, the rear wings appear a shade lighter in colour. The wing-spread measured about 22 mm. The specimen has been identified to be *Nymphula crisonalis* Walker, by the Zoological Survey of India.

Trials on Control of the Larval Pest

The pesticides chosen for trial for control of the larval pest were Benzene-hexachloride (BHC), both the ten and the five per cent product, which is being indiscriminately used in field by ' Makhana ' cultivators, and the Phosphamidon-100, available in the market under the trade name Dimecron-100. The latter drug was chosen because it is advocated to be harmless for fish life even up to a concentration of 20 ppm. (Srivastava & Konar 1965) and also because it is reported to be systemic insecticide (Anonymous 1966).

The first set of experiments was conducted in glass jars each containing 6 litres of water and two late instars of the larvae *in situ* on the leaf floated on the water. A sufficient number of zoo-plankton comprising mostly of Cyclops, Diaptomus and Ceriodaphnia were also introduced in each of these jars. The treatments given with one replication of each were : high volume spray of 200 ppm. water solution of Dimecron-100, and dusting of BHC 10 p.c. and 5 p.c. separately at the rate of 10 kg. per hectare. Two jars were kept as control without any treatment. Observations were recorded at 24 hours interval for 6 days. The 200 ppm. Dimecron spray did not seem to have any appreciable effect on the larvae and the plankton also survived. Dusting of 10 p.c. BHC proved highly lethal both for the larvae and the plankton, all dying by the second day of the treatment. In the case of 5 p.c. BHC the larvae died on the second day and the plankton by the fifth day.

The first set of experiments revealed that while BHC ten per cent dusted at the rate of 10 kg. per hectare was lethal both for the larvae and the zooplankton, Dimecron-100, sprayed in a concentration of 200 ppm. on the water surface, was innocuous. The second set of trials was therefore designed to ascertain the lethal dose of Dimecron-100 for the larvae without affecting the zooplankton. Experiments were arranged in the same manner as before and spray of three dilutions of the drug (200, 500 and 1,000 ppm.) was tried. As observed in the case of first trials, spray of 200 ppm. concentrate of Dimecron-100 did not have effect either on the larvae or the plankton. Spray of 500 ppm. concentrate of the pesticide killed the larvae by the fifth day of the treatment, with no noticeable effect on the plankton. Spray of 1,000 ppm. concentrate of the drug quickened the effect on the larvae but proved lethal for the plankton too as all of them died by the third day of the treatment.

On the basis of informations gathered from the two trials, the third set of experiments was designed to study the comparative effects of spray of 500 ppm. dilution of Dimecron-100 and BHC 5 per cent dusted at the rate of 7 kg. per hectare. The set of experiments was arranged as usual and, in addition, contained one specimen each of the fishes *Labeo rohita*, and *Cirrhina mrigala* of 8 to 10 cm length in each of the jars. Corroborating the observations of the second set of trials, spray of the 500 ppm. concentrate of Dimecron-100 killed the caterpillars on the third day of the treatment. Plankton continued to survive save for a slight mortality in one of the replications. The fishes continued to be alive in normal condition. Dusting of the BHC brought the caterpillars to morbid state on first day of the treatment and these were dead on the next day. All the plankton died out by the fourth day and the fishes also expired on the second day.

Although the above experiments were conducted in glass jars, so far as the larval pests are concerned, it is the surface application which matters and therefore the observations made in the aforesaid experiments may be taken as comparable to that of field conditions.

In absence of facilities for field studies, the above results were further tested in large iron drums where field conditions were simulated as far as practicable. Three drums were specially prepared for the purpose by laying 15 cm thick pond silt at the bottom and filled with water up to one metre depth. Infested plant of *E. ferox* with 4 to 5 larvae on the leaves, along with zooplankton consisting of Diaptomus, Cyclops, Ceriodaphnia and Sida hauled from the pond under ' Makhana ' cultivation, was also introduced into each of these drums in sufficient quantity. In addition, each of the drums further contained two specimens each of the fishes *Colisa fasciatus*, *Anabas testudineus*, *Esomus dan-*

ricus, *Barbus sophore*, *Aplocheilus panchax*, which are commonly encountered in *E. ferox* plantations, and two specimens each of *Labeo rohita* and *Cirrhina mrigala*.

Treatment comprised of spraying the surface water with a 500 ppm watery solution of Dimecron-100 in the first drum, and BHC 5 per cent at the rate of 7 kg. per hectare, with an equal quantity of wood ash for uniform dusting, in the second drum. The third drum was kept as control. After the treatment, daily observation was recorded on the behaviour of the larvae and the fishes in the drum and also on the density of plankton in the water. The larvae in both the treated drums died within four days, but observations on fish behaviour and density of plankton in the treated water was continued until the sixth day, after which the water was drained out and the number of fishes, species-wise, that survived in each of the drums was recorded. All the larvae exposed to treatment with BHC died within first two days, while those treated with Dimecron-100 first showed symptoms of dullness, and died on the third and the fourth days. The treatment, however, did not affect the plankton population in any of the drums, as their density remained the same all through the experiment. Among the fishes, casualty was noticed the next day only in *Aplocheilus panchax* exposed to BHC. Both the treatments proved innocuous for other species of fish. The above experiment was repeated again in similar conditions with identical results.

Nymphula Larvae as food for Fishes

To check if fishes would prey upon the free floating larvae, fingerlings of Indian major carps, *Cyprinus carpio*, some minnows, and *Anabas testudineus* were put in glass aquaria which had a known number of living larvae of the *Nymphula*. Excepting the fingerlings of *Cyprinus carpio* and *Anabas testudineus*, which readily took the larvae, the other fishes ignored their presence. *Anabas testudineus* ate the exposed larvae adhering to the ventral surface of the leaves. As under natural condition the larvae mostly keep themselves confined to their cases, the presence of even a good number of these fishes in 'Makhana' cultivated ponds is not likely to have much impact, even though they might eat away the few larvae hanging out of their cases.

Discussion and Conclusions

The economically important aquatic herb, *Euryale ferox*, is highly susceptible to the attack of the larva of *Nymphula crisonalis*. Infestation is confined to the early stages when the plants still have tender and membraneous leaves. With the gradual appearance of thick and stout veined leaves, in about one and a half months from the date of sprouting, the pest disappears from the plant. During the period of susceptibility, therefore, care should be taken to prevent the destruction of the crop. At the same time, care should be taken to see that the control measures adopted do not affect the indigenous fish life and other pond biota, including plankton. All experiments to control the pest were, therefore, conducted with this end in view and the choice of insecticides was limited to BHC and Dimecron-100 (Phosphamidon-100). Then ten per cent product of the former proved too strong and lethal for fishes and other biota and hence it is not recommended for use. The five per cent product of the same drug, dusted at the rate of 7 kg. per hectare, proved lethal to the caterpillar pest, without apparent harm to the crustacean plankton and the indigenous fish fauna, except for *Aplocheilus panchax*, which, by its habit of grazing along the surface film of the water, comes in closer contact with the floating dust of the BHC, and thus succumbs. Dimecron-100, sprayed as a watery solution of 500 ppm. under field conditions, proved effective in killing the larval pest within 3-4 days, without affecting the plankton or fish life.

It would not be out of place to mention that the concentration of Dimecron-100 solution used in these experiments represents the strength of the drug in the quantity of water prepared for spray, which becomes further diluted to a great extent after coming in contact with the water being treated. Since the larvae anchor to the surface floating leaves consideration of the pesticides was confined to the surface treatment only and, therefore, the exact concentration of the drug which became subsequently diluted in the treated water, was not determined. Therefore, the effect of Dimecron-100 on the fish and aquatic biota as observed in this study is not directly comparable to the results obtained by Srivastava & Konar (1956). The comparative cost involved in the use of these two pesticides, apart from labour and other incidental expenses, is for BHC 5 per cent five rupees per hectare at the current market rates. The treatment with Dimecron-100 would require 650 ml. of the drug per hectare the cost of which would come to about seventy rupees. Naturally, the higher cost involved in the use of Dimecron-100 would prompt most of the cultivators to use BHC 5 per cent. However, as BHC has persistent and cumulative effect the use Dimecron-100 despite its higher price should be encouraged. The difference in expenditure would not be much compared to the final return and the revenue derived out of the fish catch after the crop is harvested.

As *Nymphula* attacks *E. ferox* only in the early stages of growth, and infests another aquatic plant, *Nymphoides cristatum*, at other times, there is the possibility of reducing the intensity of infestation by eradicating *N. cristatum* from the waters used for *E. ferox* cultivation. This method of biological control will depend on co-operation among the pond owners and a co-ordinated approach on their part in the matter.

Acknowledgements

The author is indebted to Dr. Prem Shankar Prasad, Deputy Director of Fisheries (Research), Bihar, Patna, for allocating the project and for going through the manuscript critically. Help rendered in the field by Sri Devendra Prasad, Senior Research Assistant, and Sri Arjun Rai, Laboratory Assistant, both of this research substation, is highly appreciated. Samples of Dimecron-100 used in these trials were received from the pesticide division of CIBA of India Limited, Bombay, which is gratefully acknowledged. The author is also indebted to Dr. K. S. Pradhan, Superintending Zoologist, Zoological Survey of India, for the specific identity of the pest.

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